

High-temperature plasma of Ge generated by the PHELIX laser *

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Certain nuclear transitions, accompanied by release of large amounts of energy, can be induced by appropriate atomic resonances. One potential candidate is an isomeric state of ^{84}Rb , whose γ -decay could be initiated by resonant $ns \rightarrow 2s$ transitions in strongly ($z_{\text{ion}} > 27$) ionized Rb atoms [1]. The required degree of ionization could be achieved by heating the medium, where the ^{84}Rb isomers are created, with the PHELIX laser at GSI. Since the Rb isomers are expected to be created in the $^{76}\text{Ge}(12\text{C}, p3n)^{84}\text{Rb}$ reaction, i.e. by irradiating Ge with a carbon beam, it is the Ge plasma where one should demonstrate the ability to achieve the necessary temperatures under laser irradiation.

Here we present the results of RALEF-2D [2] simulations of a $4\text{ }\mu\text{m}$ thick Ge foil, irradiated normally by a $\lambda = 532\text{ nm}$ laser pulse of 150 J over a focal spot of radius $r_f = 100\text{ }\mu\text{m}$; the 1.4-ns long pulse was ramped with 0.2-ns linear rise and fall intervals. As a preliminary step, spectral opacities and the equation of state of Ge in the approximation of local thermodynamic equilibrium (LTE) were generated with the THERMOS code [3]. The RALEF runs were performed in the newly developed axial rz mode of the radiation transport, which was treated with 22 spectral groups and the S_{12} angular quadrature.

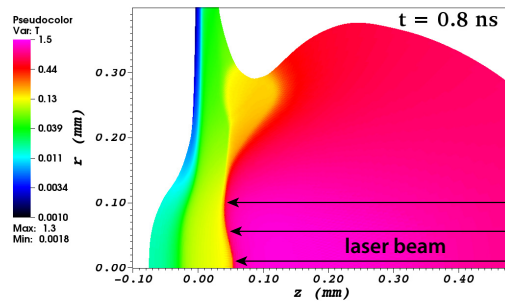


Figure 1: 2D color contour plot of Ge-plasma temperature (in keV) at $t = 0.8\text{ ns}$.

The calculated 2D temperature distribution in the Ge plasma shortly after the middle of the laser pulse ($t = 0.8\text{ ns}$) is displayed in Fig. 1. The corresponding 1D profiles along the laser-beam axis are shown in Fig. 2. The laser heated plasma consists of two distinct zones: a low-density hot corona behind the critical surface, whose temperature reaches $T_{\text{max}} \approx 1.3\text{ keV}$, and a radiation-driven

heat wave before the critical surface with a relatively high density of $\rho \approx 0.1\text{--}0.2\text{ g/cc}$, where the matter and radiation temperatures are practically equal and lie in the range $T \approx T_r \approx 100\text{--}150\text{ eV}$. The whole structure is dominated by x-ray energy transport: our simulation indicates that about 70% of the absorbed laser energy escapes the target in the form of keV-range x-rays. The calculated time- and space-integrated emission spectrum (in the direction opposite to the laser beam) is shown in Fig. 3.

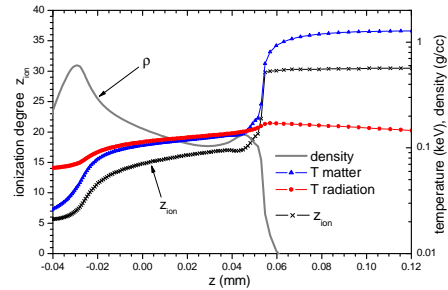


Figure 2: Profiles along the laser-beam axis at $t = 0.8\text{ ns}$.

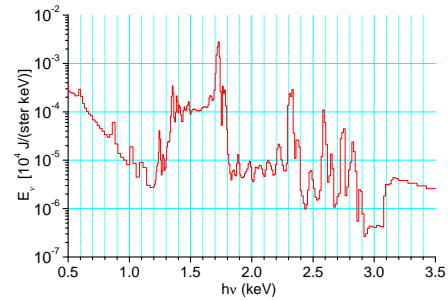


Figure 3: Time- and space-integrated emission spectrum.

Of principal interest for studying the nuclear transitions in Rb would be a narrow ablation front, where the matter temperature jumps from $T \lesssim 0.2\text{ keV}$ to $T > 1\text{ keV}$. It is within this layer that, similar to Ge, the admixture Rb atoms should undergo sharp increase in their ionization degree from $z_{\text{ion}} \approx 15\text{--}20$ up to a helium-like state with $z_{\text{ion}} = 35$ assuming LTE.

References

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